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THE EFFECT OF THE SILTING UP OF A LOWER
BENGAL RIVER ON THE PREVALENCE OF MALARIA:
WITH SOME REMARKS ON THE SPLEEN TEST, AND
THE REDUCTION OF MALARIA BY FILTERED WATER

Leonard Rogers

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tion of two small white scaled spots. The second longitudinal is for the most part white, but shows two black scaled areas on the main trunk and two dark dots on each of the branches.

The third longitudinal vein is white except for three small dark spots.

The fourth longitudinal vein has two long black spots on the main trunk and two small black spots on each of its branches. The fifth longitudinal vein has only one dark spot on the main trunk, three on its anterior branch and one on its posterior branch.

The sixth longitudinal vein has three dark spots.

The distal extremity of all the veins is light scaled, and at these points the wing fringe is interrupted by light scales.

The proboscis is black with a yellow tip.

The palpi have three white circles. The apex is white scaled, the second circle is at the junction between the apical and third segment, while the third white circle is at the junction of the third and second segments of the palpi.

The second segment of each palp is covered by larger and longer scales than the other segments.

The Antennæ have black segments surrounded by silver white long hairs.

The head is covered with white scales inserted on a dark ground.

The long frontal tufts of white hairs are well developed.

The nape is covered with brown scales.

The thorax on the dorsal aspect is covered with white scales and hairs on a dark ground and are so arranged as to show a median and two lateral darker lines. The lateral aspects of the thorax are of a dark colour.

The abdomen is intensely black and indistinctly segmented. It is covered with long white hairs.

The legs are much adorned with white scales and differ in detail in the anterior mid and hind legs. The femora and tibiae of all legs are covered with dark and light scaled areas. The first tarsal segments too have numerous white spots. The distal extremities of the second and third tarsal segments in the fore and hind legs are white, but black as these points in the mid legs. The fourth and fifth segments in the hind legs are entirely white, while they are entirely black in the other legs.

(To be continued.)

THE EFFECT OF THE SILTING UP OF A LOWER BENGAL RIVER ON THE PREVALENCE OF MALARIA; WITH SOME REMARKS ON THE SPLEEN TEST, AND THE REDUCTION OF MALARIA BY FILTERED WATER.

By LEONARD ROGERS, M.D., M.B.C.P., I.M.S.,

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THE enormous network of rivers comprised in the delta of the Ganges and Brahmaputra frequently furnish examples of the shifting of the beds of streams and the diversion of considerable bodies of water into different channels, with consequent decrease in the flow of others. The general tendency, however, is inevitably to gradual silting up of the smaller rivers by the quantities of alluvium brought down in the rainy season, and this unceasing change cannot be without effect on the health of the districts

comprised within this area. Yet but little definite knowledge on the subject appears to be on record, although according to one theory the Lower Bengal Epidemic Malarial Fever, or the "Burdwan Fever" was attributed to these changes, a supposition which I have discussed elsewhere. A recent inquiry on the effect of the silting up of the Karatoya river on the health of the Bogra district may, then, not be without some general interest.

The present inquiry arose owing to the native inhabitants having submitted a petition stating that ever since the diversion of the main current from the Karatoya river into the Bergali about half a century ago the former has gradually silted up "and has already become a source of great unhealthiness to extensive tracts on either side." This somewhat indefinite statement was on further inquiry supplemented by the additional information that the great unhealthiness had been "gradually increasing for the last forty or fifty years," in proof of which a list of villages was given "which are situated on the banks of the river, and most of which have almost been depopulated by disease. In others the number of inhabitants has been markedly reduced." Further it was said that the earthquakes in 1853 and 1897 had led to an upheaval of the bed of the river, and turned it in the dry season into "a stagnant and shallow canal," a description, however, which agrees closely with that of Hunter in 1876 as "a narrow, extremely shallow, and almost stagnant stream," so that there is no very definite evidence of appreciable recent change in the river.

On turning to the vital statistics I found that Bogra is the healthiest district in the Rajshahi division, while the death rate of the three thanas, through which the river runs, are almost identical with those to the west away from the river, as will be seen on referring to the accompanying map, although the order of the highest and lowest rates from north to south is reversed in the two cases. There was, then, no evidence of any special unhealthiness of the thanas, as a whole, through which the river runs, so that any deleterious effect must be confined to the immediate neighbourhood of the stream, and consequently would be easily found in the black-list villages which had been furnished by the district authorities. Further, if the fever had been gradually been increasing for forty or fifty years, then one might have expected to have found the commencement of an epidemic malaria such as the "Burdwan Fever" or *kala-azar*, which it would be of great importance to detect early so as to cut short the outbreak, and which might have been expected to have revealed itself in a large percentage of persons with big spleens and other symptoms of malarial cachexia. As, moreover, my inquiry had to be carried out in the month of February, which several years' figures of the fever attendance of the different hospitals of the district showed to be precisely the very month when malarial fevers were at their minimum, I had no hesitation in deciding that the spleen test would give the best indication of the relative prevalence of malarial fevers in different parts of the district, although blood films were also obtained from children, when possible, for examination for malarial parasites, a few of these only being obtained with considerable difficulty in three places where there were dispensaries in which the little operation could be quietly performed without exciting the suspicions of the people, a precaution which was specially desirable in view of the prevalence of plague in Bengal. The results fully confirmed my reliance in the spleen test.

General results of the inquiry.

Over 1,200 children were examined, and the results are embodied in the accompanying map. The number

examined in each place is given, with the percentage of them who were found to have enlargement of the spleen, so that it could be felt below the ribs, placed below. The light and dark dots indicate the site of the villages whose inhabitants were examined. The dark dots represent the black-list villages, and the light ones other control ones, some of which are situated at a distance on either side of the river varying from three to thirteen miles. In the first place it will be noted that the spleen percentages are in no case anything like so high as I met with at the same season a year before north of Calcutta in all places at a distance from the Hooghly river which were dependent on tank water. Further in no place did I meet with more than a very occasional case of the tumid belly and wasted limbs which is so characteristic of an exceptionally severe incidence of malarial fever in Lower Bengal and Assam. There was, then, no evidence of an unusual prevalence of such a severe form of malarial fever as would account for a continued depopulation of the villages, while, as a matter of fact, one of these "almost depopulated" villages produced over a hundred by no means ill-favoured children, only 26 per cent. presenting any enlargement of the spleen, and in half of these it was very slight, and in none did it even reach the navel. Yet this was the worst of the black-list villages north of Bogra town. The unhealthiness had evidently been greatly exaggerated, due apparently to the desire of the people to have the river opened up for purposes of trade.

Influence of varying rainfall on the fever death-rate.

Still there must have been some reason for the local belief in unusual unhealthiness of recent years, an explanation of which has been found in the influence of greater or less rain on the fever death-rate, as will be seen from the following table:—

TABLE I.

Year.	Rainfall in inches.	Deaths from fever.
1892	62.01 -	5,688 +
1893	85.31 +	4,647 -
1894	74.69 +	5,051 -
1895	50.09 -	5,787 +
1896	48.43 -	5,770 +
1897	57.23 -	6,015 +
1898	79.09 +	5,090 -
1899	87.64 +	4,778 -

Average for eight years 68.05 5,326

Thus in 1893 and 1894 the rainfall was excessive, and the fever rate below the average. On the other hand, in the three successive years, from 1895—97, the rainfall was deficient and the fever-rate in excess, the last of the three years being especially unhealthy, showing a cumulative effect of the abnormal meteorological conditions. Yet the unusually heavy rainfall of the next two years, 1898 and 1899, at once produced a progressive decline in the fever rate to considerably below the average. The three unhealthy years probably impressed themselves on the memory of the inhabitants and led to their petition, while the subsequent healthy one removed the evidence of the former excessive sickness before my visit. These figures have a further interest on account of the Bogra district being to the immediate south of Rungpur, in which I have showed elsewhere the present Assam epidemic malarial fever or kala-azar took its origin, arising as a result of a succession of five out of six successive years of deficient rainfall, such as have not occurred before or since as long as meteorological records are available. It is easy to conceive that if the years 1898 and 1899 had also shown a markedly deficient rainfall that the already increasing unhealthiness of the Bogra district might have culminated in another such epidemic, so that these latter figures of a district adjoining Rungpur lend considerable support to my view as to the origin of kala-azar.

Results of the spleen test.

Although there was no evidence in Bogra of any general unhealthiness of exceptional degree for Lower Bengal,

nevertheless the varying spleen rates in different parts of the district are of considerable interest, and appear to me to throw some light on the important question of the effect of the closing up of the river some years ago on the fever rate of the tract through which it runs. In the first place it will be seen that the rates are higher along the course of the river than they are at a few miles distance on either side of the stream,—with the exception of the part to the east of Bogra town between the Karatoya river and another small stream which runs between this and the Bergali river through very low-lying country, and in which the spleen rate of a village five miles to the east of Bogra was 27.5, or a little higher than that of the town itself. A second and still more important point is the steady increase of the spleen rate as we proceed from north to south along the Karatoya river. Thus, in the northernmost thana of Shibgunj 144 children were examined, all in black-list villages, but in only 22.2 per cent. was the spleen enlarged. Six miles to the west of this point, in a large village on higher ground, only 11.5 per cent. had palpable spleens, while 8 miles to the east of it the spleen rate was 13.5 per cent. Coming down to the town of Bogra, 13 miles south of Shibgunj, 25.1 per cent. of 215 children examined had enlarged spleens, while at this level the rate five miles to the west was 23.8. Three miles south of Bogra two of the black-list villages gave a rate of 41.9 per cent., yet in only one child did the spleen reach below the navel, nor did they, as a whole, show any marked signs of debility, although some of them presented the thin faces and limbs, which enable the experienced eye to at once detect a somewhat greater prevalence of malaria, which the higher spleen rate confirmed. Nine miles south of Bogra another black-list village gave a spleen rate of 36.2; while at Sherpur, 13 miles south of Bogra, the rate was 32.6 per cent. Thus the lower reaches of the river afforded villages with a considerably higher spleen percentage than the upper portions of the stream, while Bogra town itself had a rate intermediate between those of Sherpur in the south and Shibgunj in the north. There was one marked exception to this general rule, which furnishes the key to the cause of these variations. This was a village called Gokul, situated half-way between Shibgunge and Bogra, in which only 10 per cent. of 60 children examined had large spleens. The only peculiarity about this village was that although it was close to the river it was situated on distinctly higher ground than the surrounding country, the road running through it sloping down on either side. This instance proves that the elevation of the site of a village above the surrounding area rendered it less malarious, even when it is close to the river. Applying this principle, the whole of the facts noted above can easily be explained. Thus the places at a few miles distance from the river bank, on a slightly higher level than those near the stream have a low spleen rate, with the exception of the low-lying small tract to the immediate east of Bogra town, which, as already mentioned, has a high spleen rate. In this way the somewhat greater fever prevalence along the low-lying river is accounted for.

Of still greater importance and interest is the gradual decrease in the spleen rate from north to south along the river in throwing light on the effect of the diversion of most of the water from the Karatoya to the Bergali at a point to the north of the Bogra district some fifty years ago. Since that time little or no water has entered the upper reaches of the Karatoya during the eight dry months of the year, although there is a good flow of water in the rainy season. It is evident, then, that for the greater part of the year the amount of water in the Bogra portion of the stream will depend on the small tributaries entering it in its course through the district. Consequently there will be least water in the upper reaches, and most in the lower ones, or in other words the effect of drying or silting up of the stream will be

most marked in the northern thana and least so in the southern one. Further, the northern thana must be situated on somewhat higher ground than the southern to allow of the river flowing south at all, a very few feet making a considerable difference in the health, as seen in the case of Gokul, so that the lower spleen rate of the Shibgunj in the north than of Sherpur in the south, with intermediate rate in Bogra town midway between the two, is also readily explained on the same principle. We thus arrive at the conclusion that the most silted up part of the river is the most healthy one and vice versa.

This observation, however, only applies to the present time, and it does not follow that at an earlier stage of the process of closing up of the river exceptional unhealthiness may not have resulted from the change. On the contrary, it would appear to be probable that when the current in the river was first greatly reduced many years ago (for the fact that the earthquake of 1897 was followed by two years of exceptional healthiness coincident with heavy rainfall does not lend any support to the supposition that any material change in the stream took place at that time), there might have been a larger number of stagnant pools in the half empty river bed, during and at the end of the rains which would have formed good breeding ground for mosquitos, and have resulted in a temporary increased fever rate. Yet after a time, as drying up occurred, together with the slow rise in this delta, which is the primary cause of these alterations in the courses of such streams, there would be less stagnant water, and less fever, especially in the northernly and most dried up part of the river, which would eventually result in the increased healthiness appearing in the upper reaches first, which is exactly what the spleen test shows has now occurred. If this conclusion is correct, it would obviously be inadvisable to attempt the opening up again of such a stream, from the health point of view, as this would only restore the former conditions, with the result that the inevitable slow rise of this delta would once more close the stream and again bring about temporary increased unhealthiness.

Thus the gradual rise of the deltaic tracts and the accompanying closing up of the smaller streams would appear to be ultimately beneficial to health, although a temporary increased unhealthiness may result for a time, and if this conclusion is sound, the principle will be applicable to other, and perhaps more important, cases than that of the Bogra river here dealt with, so that this question appears to be worthy of attention.

The spleen test for malaria compared with other suggested methods of estimation.

Ever since Dr. T. E. Dempster worked out the effect of the Western and Eastern Jumna canals on the prevalence of malarial fever by means of the spleen percentage in 1845 and published his figures in the Indian Annals of Medical Science under the title of "Notes on the application of the test of organic disease of the spleen as an easy and certain method of detecting malarious localities in hot climates," and of which Norman Chevera writes that Dempster's spleen test "can never be neglected without danger when new ground has to be taken up for Indian cantonments," it has frequently been used without question to determine local variations in the incidence of malaria. During the last few months its value has been called in question by two writers, who have each suggested a different alternative. As I tried both of these suggestions in Bogra simultaneously with the spleen count it will be of interest to compare the results, both to see if they agree with the old test, in which case they will prove its value,

and to decide which method is the most convenient and reliable in practice, while I will also take this opportunity to reply to certain criticisms by Lieutenant-Colonel Giles, which appeared in the *Indian Medical Gazette* after my reply to Major Ross was published.

Colonel Giles makes the astonishing statement that it will puzzle me to advance any anatomical evidence to show that the chronic enlargement of the spleen is the work of the malarial parasite. I need only refer him to the admirable lectures on malaria by Thayer, in which he will find several pages devoted to the subject headed "Changes following repeated or chronic infection" and beginning with the words "The spleen is always enlarged" (page 224). Further, the section on the "Anatomical changes following acute malarial infection" also begins with identically the same words, and the whole of the changes which I have repeatedly verified in both Bengal and Assam, are very clearly described. Again, as I pointed out last year, the number of anopheles breeding under standpipes in Calcutta are so few compared with those to be found elsewhere that they are practically a negligible quantity, and Colonel Giles' argument on that point does not apply to the area in which I worked. Even in the damp climate of Calcutta standpipe pools mostly dry up before any anopheles larvae in them have time to reach maturity, so that it is easy to exaggerate their importance.

The results of the examination of children's blood for the malarial parasites after the method of Professor Koch and Drs. Christophers and Stephens were as follows: Films from 42 children in three places were obtained. All of them were under two years of age. In West Africa children of this age at Lagos were found to be infected in proportions varying between by 50 and 100 per cent. by the last-mentioned observers, so that they found that it was only necessary to examine from a dozen or two children in order to estimate the amount of infection. Most of the children I examined had suffered from fever during the previous rainy season, so that it might have been expected that many of them would show infection. As a matter of fact, I only found the parasites in four out of the 42 specimens, and in two of these cases fever had been present within a few days of the blood being taken, and a third a month before, while the fourth had suffered from fever "after vaccination." This proportion was far too small to allow any conclusions being drawn from the results with regard to the relative fever prevalence in the places where the films had been taken, so that although this microscopical work took much more time and trouble than the examination of over 1,200 children for enlargement of the spleen, the practical result was nil. Possibly if it had been feasible to have carried out the inquiry in the fever season the results might have been different, but as both this and my Hooghly inquiry of last year had to be conducted in the minimal fever season this new method of estimating malaria was useless in them. Major Ross' criticism on this point, therefore, falls to the ground. No one who has followed the recent work in West Africa and noticed the many important points in which the malaria there differs markedly from the conditions met with in India will be surprised at the additional difference in the much less common infection of young children, in the minimal fever season at any rate, in India than in Africa. Of a like nature is the difference in the frequency of enlargement of the spleen on the two continents which Dr. Daniels has recently pointed out. Nothing could more clearly show the difference between the distribution of the two forms of fever than the total absence of enlargement of the spleen in adults in Central Africa and its enlargement in over 70 per cent. of adults found by me last year near Calcutta, and the apparently nearly complete immunity of men in Africa compared with the frequency of their infection in India, but we may await the experiences of the Malaria Commission in India on this point. At any

rate the comparatively rare infection of children in the cold weather mentioned above deprives the blood test of much of its value in this country, and proportionally enhances that of the spleen test as a simple and practicable means of estimating local variations in malaria.

It will also be of interest to compare Colonel Giles' method of estimating variations in the prevalence of malaria by the total death-rate,—or more accurately by the fever death-rate, as this will exclude such widely varying factors as cholera and small-pox and "all other causes,"—with the results of the spleen test. In the following table the percentage of large spleens found in the towns of Sherpur and Bogra, in the riverine villages of Shibgunj and of Shariakandi, which is situated on a high bank of the Bergali river, are compared with the average fever death-rates per mille for ten years in the thanas of the same names.

TABLE II.

Comparison of average fever death-rates and spleen percentages.

Area.	Spleen percentage.	Average fever death-rate.
Shariakandi thana ...	10.35 ...	17.6
Shibgunj thana ...	22.2 ...	24.0
Bogra town ...	25.1 ...	24.4
Sherpur town ...	32.6 ...	29.4

This table shows such remarkably parallel figures that the only difference between the results of the two methods is that the fever death-rates only afford evidence of the comparative malariousness of the particular areas for which the figures are available, which will only be for considerable portions of a district, whereas the results furnished by the spleen test can be applied to any given part down to a few villages, and it is hence an infinitely more useful and delicate test. I am much indebted to Colonel Giles for suggesting a method of estimating malaria which so completely proves the great value and reliability of Dempster's spleen test, as a guide to purely local differences in the prevalence of the disease.

Once more, I am indebted to Lieutenant-Colonel King, I.M.S., Sanitary Commissioner of Madras, for a copy of the minutes of his proceedings for the first and second quarters of 1900, in which he discusses my Hooghly report and points out that before it appeared he had previously found an increase in the amount of fever in one town after the introduction of a good water-supply, while in four other towns there was a decreased fever prevalence under similar circumstances. With regard to one of the latter he writes: "It is a curious fact that the introduction of water-supply into Adoni—also with increase of moisture without removal of drainage—has been followed by a decrease of the fever rate. I may add that there can be no doubt that the fever of Adoni is chiefly malarial." These Madras instances prove that malarial fevers may be decreased by the introduction of a good water-supply, while the Madras climatic conditions much more closely resemble those of Calcutta than do those of the North-West Provinces in the absence of the extreme dry heat of the latter.

The effect of filtered water-supplies in reducing the fever death-rate in towns of the North-West Provinces.

Colonel Giles also discusses a table of figures from the Sanitary Reports of the North-West Provinces, and concludes that "it is therefore undeniable that, in these provinces at least, municipal malaria has increased and not diminished coincidently with the introduction of filtered water-supplies." The table gives only the figures of the average total death-rate for different series of years before and after the introduction of filtered water-supplies. Why the total death-rates are taken when those due to fever were obtainable is not explained. No corrections are made for the very marked variations in the general health of the province in different years, such as the very unhealthy year

1894, or the latter famine years. Yet the total death-rate of all the towns shows variations between one year and the next up to 60 per cent. of the whole, and in separate towns of as much as 80 per cent. Such an increase, due to exceptional general unhealthiness, is sufficient to materially raise the average rate for several successive years after the introduction of a water-supply, and thus completely invalidate the figures in Colonel Giles' table, as occurred, for instance, in the case of Cawnpore. The question is such an important one that no apology is needed for a careful analysis of the vital statistics to determine whether the fever death-rate in the large towns of the North-West Provinces, since they have been supplied with filtered water, as compared with the previous five years, is greater or less than the average of all the towns of the province during the same years in each case. As the towns with water-supplies contain about one quarter of the inhabitants of all the towns with upwards of 10,000 inhabitants, of which the vital statistics are available, a very fair comparison can be made between the two classes. If the water-supplies have increased malarial death-rates, as Colonel Giles maintains, then both the total and more markedly the fever death-rates in each or at least in most of these towns must have been greater than in those of all the towns taken together, three quarter of the inhabitants of which have not got filtered water. The total death-rate figures for the cantonments, which each contain over 10,000 inhabitants, are also supplied in my table. The reduction in the total death-rate in the Allahabad cantonment, although the water-supply is the same as that of the neighbouring town, which in Colonel Giles' table shows an increase, is of special significance in view of the fact that the supply was introduced in different years into the town and cantonment.

In the following table the figures of both the omitted cantonments and of Dabra (whose supply I believe is not filtered) are added to those of Colonel Giles' table, making ten places in all. In the first half of the table the total death-rate figures are given, and the second half those of the fever death-rate. The first two columns give the same figures as in Colonel Giles' table, while the third one gives the difference between those of columns 1 and 2, that is, the average increase or decrease in the total death-rate since the introduction of the water-supplies compared with that of the previous five years. In columns 4, 5 and 6 similar average total death-rate figures of all the large towns are given for the same series of years in each case. By subtracting the figures of column 6 from those of column 3, we obtain the greater or less increase of the total death-rate in each town since the introduction of the water-supply as compared with the rates for the same series of years in the whole of the large towns. These figures are given in column 7, from which it appears that in six out of the ten cases the total death-rate of the towns with the water-supplies has increased less rapidly than in the whole of the towns of the province, while in four cases the increase has been greater, or, in other words, the general death-rate of all the towns, as a whole, has increased more rapidly than in the majority of those with filtered water, the same series of years being compared in each case. If then Colonel Giles' assumption that the total death rate figures can be taken as a guide to the death-rate from malarial fevers is accepted, the introduction of filtered water has, in the majority of cases, caused a decrease in the prevalence of malaria. However, the total death-rates include those from cholera, small-pox and bowel-complaints, while the proportion of deaths returned under the heading of "all other causes" varies very widely in different towns, and in the case of Beuares in 1899 was no less than 45 per cent. of the total death-rate, which shows what a rough guide the total death-rate figures must be of the mortality from malarial fevers, so that it is worth while to examine the figures of the fever death-rates in a

similar manner to that adopted above in the case of the total death-rates. These figures are given in the second part of the table for precisely the same periods in every instance as in the first part. In column 10 will be found the increase or decrease in the average fever death-rate before and after the water supply was introduced, and it will be seen that in four instances there was an actual reduction in the fever rate, while in four others, the increase is comparatively small as compared with the total death-rate. In column 13 will be found the parallel fever death-rate figures for all the towns taken together for the same periods in each case, from which it is at once evident that *there has been a greater increase in the fever death-rate in all the towns taken together than in those with filtered water in every instance except that of Agra town.* The increase or decrease of

in a diminution of the general death-rate." Such diminution will have an even more evident effect on the fever death-rate, so that there is evidently good reason to believe that the relative decrease in the fever death-rate of the towns with filtered water, as compared with those without it (with one exception) which I have demonstrated above has actually taken place, is due to a reduction in the death-rate from malarial fever. Still the question is too important for any assumption, however reasonable, to be accepted if it can be put to the test of facts, so we may proceed to inquire if there is any other common disease attended by marked fever, and so liable to be returned under this heading, which could have been decreased to such an extent as to account for the diminished relative death-rates in the towns with filtered water supplies. *Post mortem* evi-

	TOTAL DEATH-RATE FIGURES.							FEVER DEATH-RATE FIGURES.							
	TOWNS WITH FILTERED WATER.				ALL TOWNS OVER 10,000 POP.			TOWNS WITH FIL-TERED WATER.			ALL TOWNS.				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Years with water-supply up to 1899.	Average death-rate since the introduction of the water-supply to 1889.	Average death-rate in the pre-vious five years.	Increase or decrease per mille of death-rates.	Average death-rate in all the towns for the same period in each case as in column 1.	Average death-rate in all the towns for previous five years as in column 2.	Increased death-rate per mille in all towns.	Greater or less increased death-rate in filter water towns than in all the towns.	Fever death-rates as in column 1.	Fever death-rates as in column 2.	Fever death-rates as in column 3.	Fever death-rates as in column 4.	Fever death-rates as in column 5.	Fever death-rates as in column 6.	Fever death-rates as in column 7.
Dehra ...	4	27.60	26.00	+1.60	40.36	36.73	+3.63	-2.03	20.13	20.36	-0.25	28.99	25.62	+3.37	-3.62
Meerut ...	4	35.06	32.13	+2.93	40.36	36.73	+3.63	-0.70	26.61	24.60	+2.01	28.99	25.62	+3.37	-1.36
Lucknow ...	5	43.79	44.68	-0.89	39.17	37.47	+1.70	-2.59	30.85	32.65	-1.20	28.15	26.61	+1.54	-2.74
Lucknow Can-tonment.	5	16.88	21.22	-4.34	39.17	37.47	+1.70	-6.04	13.43	13.22	+0.21	28.15	26.61	+1.54	-1.33
Cawnpore ...	6	47.83	41.17	+6.66	40.78	35.34	+5.44	+1.22	38.10	38.40	-0.30	29.04	24.74	+4.30	+4.60
Benares ...	7	48.81	39.99	+8.82	39.20	35.91	+4.19	+4.63	27.82	26.60	+1.22	27.79	25.70	+2.09	-0.87
Allahabad ...	9	28.70	25.77	+2.93	38.40	37.73	+0.67	+2.26	21.65	21.52	+0.13	27.12	26.71	+0.41	-0.28
Allahabad Can-tonment.	8	14.33	15.14	-0.71	38.64	37.67	+0.97	-1.68	10.04	12.37	-2.33	27.38	26.27	+1.11	-3.44
Agra ...	9	35.46	32.23	+3.23	38.40	37.73	+0.67	+2.56	26.55	23.89	+2.66	27.12	26.71	+0.41	+2.25
Agra Canton-ment.	6	26.86	23.99	+2.87	40.78	35.34	+5.94	-2.57	21.28	17.08	+4.20	29.04	24.74	+4.30	-0.10

the fever death-rates of the towns with water-supplies compared with those of all the towns is shown in column 14, from which it appears that the relative decrease in the fever death-rate in four cases, as compared with that of all the towns, is more than 10 per cent. of the whole fever death-rate, namely, in Lucknow and Allahabad cantonments, Cawnpore and Dehra; in Lucknow the decrease is 9 per cent., and in Meerut 5 per cent. The case of Cawnpore is specially remarkable, for, while the total death-rate shows relative increase of 1.22, the fever death-rate shows a relative decrease of 4.60 per mille, showing how inaccurate it is to deduce an increase in the malarial fever death-rate, from a small increased total death-rate.

The final result of the analysis of the figures is that, while in four cases there has been an actual decreased fever death-rate since the supply of good water, five out of the six remaining towns show a less increase of the fever death-rate than do the whole of the towns, during the same period. This difference which would be still more marked if the fever rates of the towns without filtered water alone could be compared with those with the good water-supplies. Now Colonel Giles writes that "it is impossible to imagine that any diminution in malarial fevers and splenic enlargement could fail to show itself

dence alone will furnish evidence as to the frequency of deaths from different kinds of fever, and as I know of no such figures for the North-West Provinces towns I have analysed five hundred successive recent *post mortems* at the Medical College, Calcutta, where malarial diseases are at least as common as in the North-West Provinces. The result is that phthisis caused more deaths than did malaria in all its four forms, while pneumonia and inflammations of serous membranes each caused about the same number of deaths as malaria, and these four, together with septic inflammatory affections, comprised more than 90 per cent. of all deaths likely to be commonly returned under the head of fever. The relatively reduced fever rate following the supply of filtered water-supplies must, then, be due to a considerably lessened death-rate under one or more of these heads. Now it is a well known fact that phthisis is increased by increased dampness of the soil, so that the introduction of these supplies would tend rather to increase than to decrease this very common and fatal disease. Further, neither pneumonia, pleurisy, &c., or septic diseases are likely to be reduced by filtered water-supplies. The only common cause of death from any febrile disease, a diminution of which could possibly explain the relative decrease in the fever death-rate after the introduction

of filtered water, then, is malaria, and the North-West Provinces results amply confirm my conclusions with regard to the reduction of malaria, as judged by the spleen test, along the banks of the Hooghly wherever filtered water has been supplied, and thus indirectly confirm the accuracy of the spleen test itself.

One point only remains for consideration, namely, is there any special cause for the exceptional increase in the fever death-rate in Agra, other than an increase in the malaria? There is; for in the discussion on enteric fever among British troops in this town in the 1899 report of the Sanitary Commissioner with the Government of India, it is stated that "since the introduction of, in 1894, into cantonments of the municipal piped water, the number of admissions and deaths have more than doubled," while this fever is so much more fatal than malaria that a comparatively small number of cases would materially affect the fever death-rate, and every day the not infrequent occurrence of enteric fever in natives is being confirmed, while I have recently proved its presence is not at all rare among them in Calcutta. Further, that the increase of enteric in Agra is caused by the filtered water is proved by Mr. Hankin having found the organism of the disease ten times in one year in the Jumna river close above the intake of the Agra supply, and also in the filtered municipal water-supply in Agra every month from March to September 1899, and that, too, in spite of the well-known great difficulty in isolating this organism from water. Once more the same bacteriologist has found the same organism in other filtered water-supplies in the North-West Provinces towns, so that there may very likely have also been some increase of enteric fever in them which would tend to mask the reduction in that of malarial fevers, and hence the latter may have been even greater than is shown in column 14 of the table given above. That enteric fever may be increased by supplies of water from Indian rivers with a large riparian village population is also suggested by the fact that the Calcutta water-supply very frequently contains the bacillus coli communis, which is generally regarded as being derived from faecal contamination when found in water, and hence evidence of a possible, not to say probable, occasional presence of the enteric organism. This is a very serious matter, and certainly needs to be carefully excluded before any increased fever death-rate in towns supplied with filtered water is attributed to a greater prevalence of malaria, especially in view of the now proved reduction in the latter disease consequent on the introduction of filtered water in both certain areas north of Calcutta, and in the large towns of the North-West Provinces.

That it is not altogether easy to explain this reduction in the malaria in our present state of knowledge only enhances the value of the fact as an indication that we have still something to learn about malaria, in spite of the recent great advances. My Bengal observations only showed that the spleen rate was reduced by pure water, with doubtless a most beneficial result on the health of the people. The analysis of the North-West Provinces figures proves that the malarial fever death-rate is also reduced. It is difficult to see how primary malarial infections could have been reduced by the filtered water-supplies, especially in the absence of drainage, but there can be no doubt that relapses are much more frequent than primary infections, and that they will depend largely on the general health of the patient. Any general hygienic cause, then, such as an improved water-supply, may materially lessen the number of relapses. Further, it is certainly an exceptional event in India for a patient to die in his first attack of malarial fever compared with the numbers who succumb to repeated attacks, so that the death-rate would be reduced in a still greater proportion by any general cause which lessened the tendency to relapses.

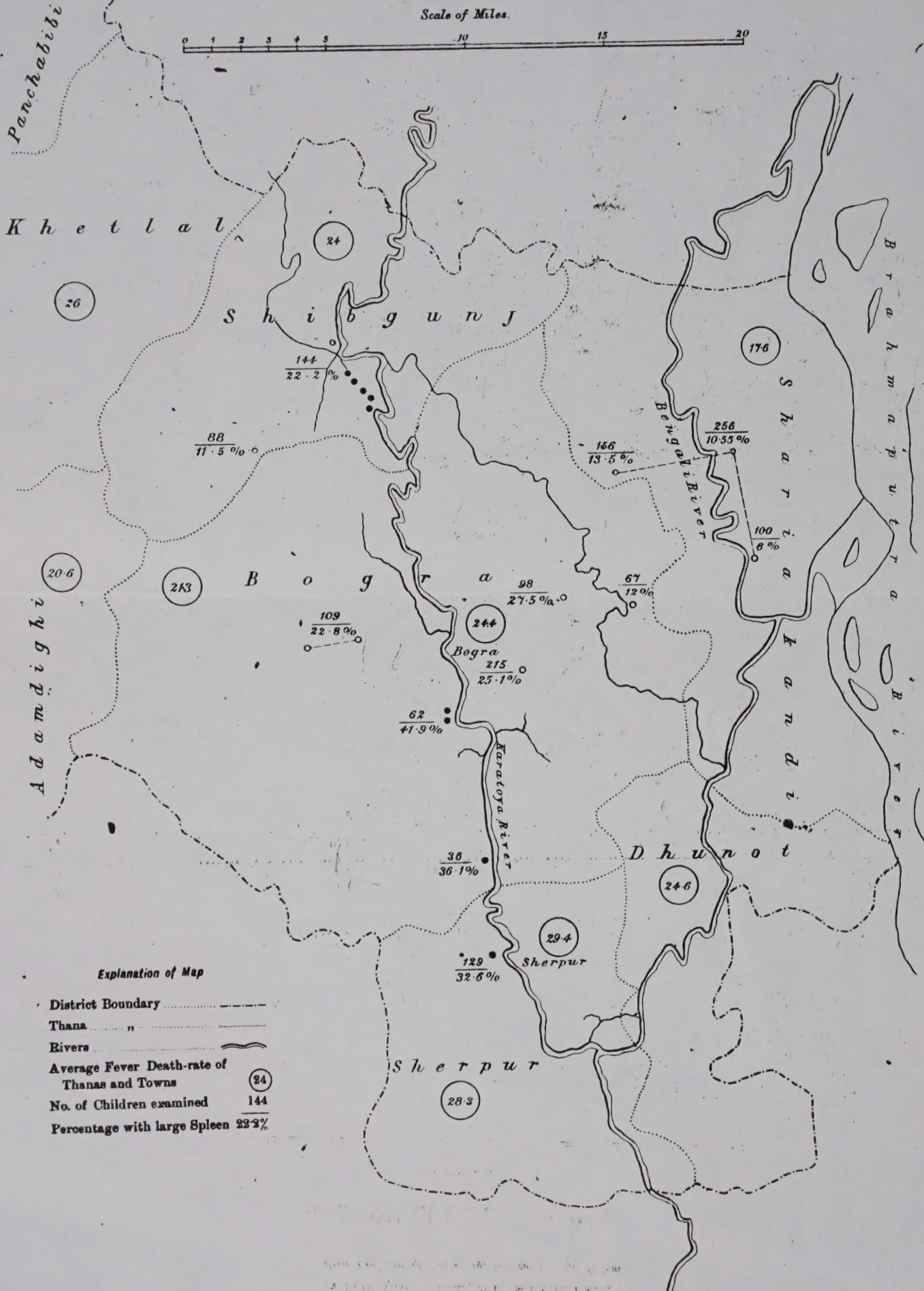
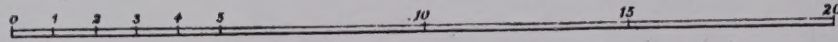


THE EFFECT OF THE SILTING UP OF A LOWER BENGAL RIVER ON THE PREVALENCE
OF MALARIA; WITH SOME REMARKS ON THE SPLEEN TEST, AND
THE REDUCTION OF MALARIA BY FILTERED WATER.

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MAP OF BOGRA DISTRICT.

Scale of Miles.



Explanation of Map

- District Boundary
- Thana
- Rivers
- Average Fever Death-rate of Thanas and Towns
- No. of Children examined
- Percentage with large Spleen

